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Procédé d'enregistrement optique à variation d'intensité lumineuse

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(56) References cited:

EP-A- 0 317 344	**EP-A- 0 548 981**
EP-A- 0 594 132	**FR-A- 2 508 218**
US-A- 4 443 870	**US-A- 4 587 648**
US-A- 4 947 384	**US-A- 5 040 165**
US-A- 5 233 593	**US-A- 5 367 514**

- **PATENT ABSTRACTS OF JAPAN vol. 015, no. 322 (P-1239), 16 August 1991 & JP 03 116529 A (TOSHIBA CORP), 17 May 1991,**
- **PATENT ABSTRACTS OF JAPAN vol. 016, no. 442 (P-1421), 16 September 1992 & JP 04 153919 A (NIPPON TELEGR & TELEPH CORP), 27 May 1992,**
- **PATENT ABSTRACTS OF JAPAN vol. 017, no. 585 (P-1632), 25 October 1993 & JP 05 166187 A (MATSUSHITA ELECTRIC IND CO LTD), 2 July 1993,**
- **PATENT ABSTRACTS OF JAPAN vol. 016, no. 555 (P-1454), 25 November 1992 & JP 04 212718 A (NIPPON TELEGR & TELEPH CORP), 4 August 1992,**
- **PATENT ABSTRACTS OF JAPAN vol. 018, no. 042 (P-1680), 21 January 1994 & JP 05 266490 A (FUJI ELECTRIC CO LTD), 15 October 1993,**
- **PATENT ABSTRACTS OF JAPAN vol. 009, no. 334 (P-417), 27 December 1985 & JP 60 157740 A (RICOH KK), 19 August 1985,**

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Description

[0001] The present invention relates to an optical disk drive for a disk that permits overwriting of a sector of the disk.

[0002] As the above optical disk (optical information recording media), a phase transition type system using a chalcogenide as a recording thin film material is known well. This recording thin film is a photo-sensitive layer formed on a substrate, which transfers into a crystal state or an amorphous state by irradiation with a light beam such as a laser beam. The recording layer of the overwritable optical disk of a phase transition type can record data usually by using a crystal state for a non-recorded state and an amorphous state for a recorded state. The amorphous state is generated by irradiating a laser beam to melt the recording layer followed by rapid cooling down thereof. The crystal state is generated for erasing the recorded data by irradiating a laser beam at a lower power to raise the temperature of the recording layer.

[0003] One of the merits of the phase transition type system is that only one laser beam is required and that the disk can be overwritten easily. If the laser beam power is modulated between two levels, i.e., a recording level and an erasing level, according to the write data, erasing old data and recording new data can be performed simultaneously by irradiating the modulated laser beam at the track of recorded data (Tokukaishou 56-145530). The phase transition type optical disk having the above merits is widely used for recording (i.e., writing) and reproducing (i.e.,reading) document files, picture image files and other data files.

[0004] The overwritable optical disk usually has a guide track in a spiral or in circles that is detected optically, for high density recording and for necessity of dispersed recording. The optical disk drive (i.e., optical disk reader/writer) irradiates a laser beam focused in a diameter of less than 1 μm to the recording layer on the guide track of the optical disk for writing or reading of data.

[0005] It is common to divide a track into sectors to record variable length data effectively. Each sector that has usually a memory capacity of 512 bytes or 1024 bytes including the sector ID area including a track address and a sector address, and a recording area for writing and reading of data. An address portion that indicates a physical address of a sector is preformatted at the manufacturing stage.

[0006] Usually, a recording format for data recorded in the recording area includes a synchronizing signal (i.e., VFO) portion for drawing in of PLL (Phase Locked Loop), a data head indicating mark (i.e. DM) added to the head of the write data as a kind of synchronizing signal, a modulated data portion and a resynchronizing signal for word synchronizing. In the process of data recording, an address of a target sector ID is read and the data is written into the recording area of the target sector after detecting the address.

[0007] There are two recording methods, i.e., a pulse position modulation and a pulse width modulation. In the pulse position modulation, mark positions are detected for reading of data . On the other hand, both ends of marks are detected in the pulse width modulation. The pulse width modulation has an advantage in record density.

[0008] The recording and reproducing method of the phase transition type optical disk in the prior art is explained below, referring Fig.14 and 15. Fig.14 illustrates a block diagram of a reader/writer (optical disk drive) in the prior art. Fig.15 shows write data, a laser power and a recording state of the optical disk for explaining the write/read operation.

[0009] As shown in Fig.14, a system controller 4 connected to a host computer outputs the write information as a binary signal. This write information is provided with error correction information, then encoded in a encoder 7a with e.g., 1-7 RLL. A composer 8 adds a synchronizing signal (VFO) to each data block to be written into each sector so as to generate write data lla. A laser power controller 12 controls the laser housed in a optical head 3 to modulate the intensity of the laser according to the write data lla. The system controller 4 also controls a spindle motor 15 to rotate the optical disk.

[0010] If the strong laser beam (at laser power Pp) focused by the optical head 3 is irradiated to the recording layer of the optical disk 1 to raise the temperature of the recording layer above its melting point, the spot irradiated by the laser beam is melted and cooled rapidly, and assumes the amorphous state as a recorded mark 20. On the other hand, if the laser beam (at laser power Pb) is focused and irradiated to raise the temperature of the recording layer above the crystalization temperature but below the melting point, the recording layer at the irradiated spot assumes the crystal state. Data recording is performed in the above mentioned way using a difference between the crystal state and the amorphous state.

[0011] Data reproducing(reading) from the optical disk is performed using the difference of the optical character of the recording layer between the crystal state and the amorphous state. A weak laser beam (at laser power Pr) is focused and irradiated to the optical disk and a change of a reflected beam is detected as a read RF signal 14 of the recorded data. Then, the signal is converted to a binary signal in a read signal processor 13; it is further processed for decoding and error correction to be a desired read information 6. A similar weak laser beam is irradiated to the optical disk for reading address information when the beam scans the address portion between sectors 18 of the optical disk during the recording process.

[0012] However, it is known that repeated recording in a sector of the optical disk of the phase transition type may generate a deterioration that is unique to the phase transition type optical disk. This deterioration causes a reading

error. The area of this type of deterioration usually spreads according to the number of times recordings is repeated. Three main patterns of the deterioration are as below:

(1) a defect of the recording layer is generated in a record start portion of a chain of recording areas due to the repeated recording; the defect spreads backward (direction of laser scanning on the disk);
(2) a defect of the recording layer is generated in a record end portion of a chain of recording areas due to the repeated recording; the defect spreads forward (opposite direction of laser scanning on the disk);
(3) a defect of the recording layer is generated in an area where the same pattern mark train is recorded; the defect spreads forward and backward.

[0013] Usually rewriting of the optical disk is performed by sectors. Therefore, the whole sector is rewritten even if the recorded data is only changed partly. Especially, a TOC (Table Of Content) area and a directory area of the disk are often written by similar data repeatedly. The above deterioration pattern (3) occurs in such areas.

[0014] It is understood that these three patterns of deterioration are all due to a slow migration of the material that forms the recording layer in the laser scanning direction or the opposite direction. However, what drives the recording layer material to migrate during laser irradiation is not known. Some driving forces are conceivable such as surface tension due to a thermal gradient in the recording layer during the laser irradiation or a deformation of the layers making up the optical disk due to a thermal load. If the recording layer has deteriorated, the necessary reflection of the laser beam corresponding to the recorded or non-recorded state of the optical disk cannot be obtained. Some recording methods are proposed to solve these problems so that the performance of rewriting improves. For example, as a solution of the above deterioration pattern (3), there is an optical disk drive that can suppress the deterioration by altering the start position of the VFO recording at every recording (Tokukaishou 63-229625). As a solution of the above deterioration pattern (2), there is an optical disk drive that can suppress the effect of deterioration of the waveform that spreads forward (direction toward the record start point) from the record end point by recording a fixed length of dummy data (Tokukaihei 2-297724).

[0015] In the above writing methods of the prior art, the start position of the VFO writing is altered at every writing, or the fixed length of dummy data is added to the end of the data block to suppress the deterioration of the read data due to the repeated recording. Therefore a dummy data area is necessarily added to the record area of the data block. This means that the recording capacity (byte number) is substantially decreased.

[0016] The object of this invention is to provide a recording/reproducing method and apparatus that can suppress the deterioration of the overwritable phase transition type optical disk due to the repeated recording so that the number of possible overwriting is increased.

[0017] In order to achieve this object, a first aspect of the recording/reproducing method of the present invention is characterized in that the write data to be recorded into each sector of the optical information recording medium (i.e., optical disk) includes original write data and dummy data added to the head of or following the original write data, and the light intensity (i.e., energy of the light irradiation) is increased or decreased slowly in the dummy data area heading or following the write data.

[0018] By the above method, the thermal stress to the recording layer as well as the material migration of the recording layer is decreased closes to the head or the end of the dummy data. Consequently, concentration of the thermal stress in the recording layer at the record start or end point is avoided, so that the deterioration of the recorded data at the record start or end point due to the repeated recording can be suppressed.

[0019] A second aspect of the recording/reproducing method of the present invention is characterized in that the light irradiation energy for forming the mark of the synchronizing signal is smaller at least in a head area than the light irradiation energy for forming the shortest mark of the original data. By this method, the thermal stress in the area of the synchronizing signal is smaller than in the area of the write data following the synchronizing signal. Consequently, the synchronizing signal can be read correctly after repeated rewriting.

[0020] The recording/reproducing apparatus according to the present invention includes devices for performing the above recording/reproducing methods.

[0021] This invention will be described in detail by referring to following figures, where

Fig.1 is a block diagram illustrating the optical disk drive for selecting non-inverted or inverted write data;
Fig.2 is a flow chart of the operation performed by the optical disk drive illustrated in Fig.1 for rewriting a sector of the optical disk;
Fig.3 is a timing chart for the write data, the inverted write data, the laser power and the written state of the optical disk in the optical disk drive illustrated in Fig.1;
Fig.4 is a block diagram illustrating the optical disk drive comprising a dummy data generator;
Fig.5 is a flow chart of the operation performed by the optical disk drive illustrated in Fig.4 for rewriting a sector of the optical disk;

Fig.6 is a block diagram of the dummy data generator of the optical disk drive illustrated in Fig.4;

Fig.7 is a timing chart of each signal of the dummy data generator illustrated in Fig.6;

Fig.8 is a timing chart for the write data, the laser power and the written state of the optical disk in the optical disk drive illustrated in Fig.4;

Fig.9 is a timing chart for the write data, the laser power and the written state of the optical disk in a variety of the optical disk drive illustrated in Fig.4;

Fig.10 is a block diagram illustrating a variation of the optical disk drive illustrated in Fig. 4 according to the present invention;

Fig.11 is a timing chart for the write data and the laser power of the optical disk in the optical disk drive illustrated in Fig.10;

Fig.12 is another variation of the timing chart for the write data and the laser power of the optical disk in the optical disk drive illustrated in Fig.10 according to the present invention;

Fig.13 is a block diagram illustrating another variation of the optical disk drive illustrated in Fig. 4;

Fig.14 is a block diagram illustrating an optical disk drive of the prior art;

Fig.15 is a timing chart for the write data, the laser power and the written state of the optical disk in the optical disk drive illustrated in Fig.14;

Fig.16 is a block diagram illustrating the optical disk drive of a further embodiment according to the present invention;

Fig.17 is a flow chart of the operation performed by the optical disk drive illustrated in Fig.16 for rewriting a sector of the optical disk;

Fig.18 is a timing chart showing variation in the laser power when writing a mark train including the synchronizing signal and the data with the optical disk drive illustrated in Fig. 16;

Fig.19 is a chart showing a record format in a data portion of a sector when writing a mark train including the synchronizing signal and the data with the optical disk drive illustrated in Fig.16;

[0022] A block diagram of an optical disk drive or an optical disk reader/writer (i.e. recording and reproducing apparatus) for selecting non-inverted or inverted write data is illustrated in Fig.1. A flow chart of the process to rewrite a sector performed by the reader/writer is illustrated in Fig.2. In step 201, the reader/writer detects ID (address data) of the sector to be rewritten. In step 202, a system controller 4 that is connected to a host computer outputs write information 5 in the form of binary data. This write information 5 is provided with information for error correction in step 203 and it is encoded in step 204. In step 205, each data block to be written in a sector is provided with a synchronizing signal (VFO) and other signals, so that write data 11a is made in a composer 8; the synchronizing signal is generated in a synchronizing signal generator 2. The above operation of this reader/writer is similar to the prior art; the following operation is different.

[0023] As shown in Fig.1, the write data 11a is divided into two paths; one path connects to a selector 9 directly; another connects to a selector 9 via an inverter 10 that makes inverted write data 11b (step 207 in Fig.2). The selector 9 is triggered by detection of the address data of the sector to be rewritten. It selects the, non-inverted write data or the inverted write data at random, and holds the selected data until the data is written into the sector. Therefore it is determined by the selector 9 in step 206 whether the write data is inverted or not before writing.

[0024] If a reader/writer that accesses sectors of a optical disk (i.e. optical information recording medium) at random is used, selecting the non-inverted write data or the inverted write data alternately by the selector 9 can generate substantially the same situation as selecting at random. In this case there is no need to provide means such as a random number generator. An output of the selector 9, i.e. either non-inverted write data 11a or inverted write data 11b, is given to a laser power controller 12, that performs laser intensity modulation driving a laser housed in a optical head 3 (step 208). Thus the data string is written into the sector of the optical disk.

[0025] Fig.3 shows an example of a time chart that includes write data, laser power and written state. Laser power when the inverted write data is selected by the selector 9 has an opposite phase to that when the write data 11a is selected, concerning the level of Pp and Pb. Consequently, amorphous written marks 20 are formed in the opposite phase to each other on the sector of the optical disk.

[0026] Therefore, each position in the sector has substantially the same probability of being formed with a written mark, even if the same information is written repeatedly in a sector. Thus damage due to the repeated rewriting in the particular position does not occur.

[0027] A concrete example will be explained below. The substrate of the optical disk whose diameter is 130 mm was made of polycarbonate. This polycarbonate substrate was preformatted with uneven phase pits as address information and guide grooves for writing were formed in a sector area. A reflection layer, a photosensitive layer and a protection layer were formed on the substrate. Then, a protecting plate was bonded thereto. The reflection layer was formed with Al; the protection layer was formed with ZnS-SiO_2; the photosensitive layer was formed with Te-Sb-Ge.

[0028] The optical disk made by the above process was rotated at a linear speed of 5 meters per second. A laser

beam that has a 680 nm wave length was focused on the disk for writing by using a lens that has the numerical aperture (NA) of 0.6. The laser power for reading and writing was adjusted to Pp=11mW, Pb=4mW and Pr=1mW. Pulse width modulation (PWM) with 1-7 RLL (Run Length Limited) was used for write data modulation. The shortest mark length and the shortest mark distance were set both at 0.6 μ m.

[0029] After rewriting the same information into the same sector repeatedly using the above conditions, the jitter value was measured. The measurement was performed in five different numbers of rewriting times, i.e. one, ten, a hundred, a thousand and ten thousand. The information written in a sector had 2970 bytes.

[0030] Table 1 shows a comparison of jitter values in this example (example 1), in another example that will be explained later, and in the prior art. In this table, σ represents standard deviation of jitter values on zero cross point of read data signal; Tw represents the window width of the detecting system.

Table 1

Jitter (σ/Tw)					
Times of rewriting	1	10	100	1,000	10,000
Prior art	6.4	7.3	7.4	8.5	12.8
Example 1	6.2	7.1	7.0	7.4	8.3
Other example	6.2	7.2	7.1	7.2	7.6

[0031] As seen in Table 1, the jitter value in the prior art increases as the number of times of rewriting increases. However, the increasing rate of the jitter value in example 1 is much lower than in the prior art. This means that deterioration of the read data signal due to repeated rewriting is suppressed.

[0032] If a method disclosed in Tokukaihei 2-94113 that varies a write start point at random, and the method of the above embodiment of this invention are combined, deterioration of the photosensitive layer may further be suppressed, since the probability of forming a boundary between the area melted/hardened repeatedly and the non-melted area may be substantially uniform over the whole writing area. Such a configuration can be obtained by adding a delay circuit that can control the delay time by steps next to the composer 8, and changing the delay time at random in each sector rewriting. Jitter values of the "other example" in Table 1 are measured in this configuration. It is clear that the increasing rate of the jitter value in the other example is lower than in example 1.

[0033] In this embodiment, written mark distance is not varied when write data are inverted, since pulse width modulation is used. Therefore, one decoding method can be used for both non-inverted write data and inverted write data, so the decoder circuit does not need to be complicated.

[0034] Fig.4 illustrates a block diagram of a reader/writer with a dummy data generator. A flow chart of the process to rewrite a sector performed by this reader/writer is illustrated in Fig.5. After detecting ID (address data) of the sector to be rewritten in step 501, a system controller 4 that is connected to a host computer outputs write information 5 in the form of binary data (step 502). This write information 5 is provided with an information for error correction in step 503 and it is encoded in step 504. In step 505, each data block to be written in a sector is provided with a synchronizing signal (VFO) and other signals, so that write data 11a are made in a composer 8. Laser intensity is modulated according to this write data (step 507). The laser beam is focused on the optical disk, and thus the data are written into the sector of the optical disk. The above operation of this reader/writer is similar to the prior art; the following operation is different.

[0035] A dummy data generator 21 generates dummy data that is added to the head to the writing data and a second composer 22 composes the write data and the dummy data (step 506). The composed data are given to a laser power controller. Dummy data means data that are added to the original write data, including the synchronizing signal. An example of the configuration of the dummy data generator 21 is illustrated in Fig. 6. Wave forms of signals in the circuit illustrated in Fig. 6 are shown in Fig.7.

[0036] Dummy data generating signals 27 from a system controller 4 are given to the dummy data generator 21. These signals 27 include a clock signal 24 that corresponds to the narrowest pulse width and an address information detecting signal 30. The clock signal 24 is inputted to a frequency demultiplier 28, a demultiple ratio set circuit 33 and a delay circuit 32. The proper delay time for adding dummy data to the head of the write data is set in the delay circuit 32. When an output signal 31 of the delay circuit 32 is added to the frequency demultiplier 28 and the demultiple ratio set circuit 33, demultiplying of the clock signal 24 starts.

[0037] The demultiple ratio set circuit 33 provide the frequency demultiplier 28 with a demultiple ratio setting signal that decreases the demultiple ratio slowly. Thus, the frequency demultiplier 28 outputs the pulse signal 25, whose period decreases slowly as shown in Fig.7. This pulse signal 25 is given to an invert signal detector 29 that generates a pulse signal whose pulse width corresponds to several clock signals when the pulse signal is inverted. This pulse signal becomes dummy data 26.

[0038] Fig.8 shows an example of a time chart that includes write data, laser power and written state by this reader/

writer. As known from Fig. 8, the ratio of the pulse interval and the pulse width, i.e., the ratio of a mark distance (for spacing) Sw and a mark length Mw, is larger at the position closer to the head of the dummy data.

[0039] Therefore thermal stress is smaller in a portion closer to the head of the dummy data, so that material migration of the photosensitive layer is smaller in the portion closer to the head of the dummy data. Consequently, this avoids the damage of the photo-sensitive layer concentrating at a start point of the written data, and the deterioration of the photo-sensitive layer occurring due to repeated rewriting.

[0040] A concrete example will be explained below. The optical disk, modulation system and laser power are the same as in the before mentioned example. A random signal was used as the write information. The write data with the dummy data as shown in Fig. 8 were rewritten thirty thousand, fifty thousand, seventy thousand and a hundred thousand times. Then, the length of the deterioration area whose read signal is distorted in the head of the write data including the dummy data was measured. The length of the dummy data is 50 μ m on the disk. The ratio of the mark distance Sw and the mark length Mw was set larger in the portion closer to the head of the dummy data.

[0041] Table 2 shows a comparison of the length of deterioration area measured in this example (example 2), in another example that will be explained later, and in the prior art.

Table 2

Length of the deterioration area (μm)				
Times of rewriting	30,000	50,000	70,000	100,000
Prior art	5	10	55	105
Example 2	0	5	10	50
Other example	0	0	10	30

[0042] As seen in Table 2, the length of the deterioration area in this example is shorter than in the prior art. This means that deterioration of the photo-sensitive layer due to repeated rewriting is suppressed.

[0043] In this embodiment, dummy data are added to the head of the write data corresponding to the case in which deterioration of the photo-sensitive layer tends to occur in the head portion of a sector. However, it is also possible that the deterioration tends to occur in the tail portion of the sector due to the layer construction of the optical disk. In this case, the deterioration is suppressed by adding dummy data to the end of the write data. and by setting the ratio of the mark distance Sw and the mark length Mw larger in the portion closer to the end of the dummy data.

[0044] The dummy data in these embodiments have a constant mark distance Sw and a variable mark length Mw. However, it is possible to fix the mark length Mw and alternate the mark distance Sw. Any other pattern such as random signal pattern or DC signal pattern can be used as long as it can soften the sudden change in thermal stress to the photo-sensitive layer at the start or the end point of writing.

[0045] A configuration illustrated in Fig.10 shows one embodiment of the invention. This configuration does not include the dummy data generator 21 and the second composer 22 illustrated in Fig.4, but includes a pattern generator 34 that increases or decreases the intensity of the laser power step by step, a second laser power controller 35 and a selector 36 for switching the first and second laser power controller. As shown in Fig.11 or 12, the laser intensity is increased or decreased slowly in the dummy portion connected to the head or the tail of the write data portion, and the selector 36 is switched, so that the modulated laser intensity waveform 36a is gained. This laser intensity waveform 36a can be used to perform the same effect as the above mentioned embodiment where the start point of writing in a sector is altered at random.

[0046] It is also preferable to combine this embodiment and the above mentioned embodiment. This result is showed in Table 2 as the "other example". It can be seen that the deterioration of the photo-sensitive layer is suppressed more effectively in the other example by decreasing the thermal stress in the head of the dummy data more smoothly.

[0047] The length of the dummy data string can be altered at random in every rewriting to get the same effect as altering the start point of writing at random.

[0048] In this embodiment, the mark distance as well as the mark length in the end of the dummy data is set identically as in the synchronizing signal portion for preventing the rapid change in thermal stress between the dummy data and the synchronizing signal portion, so as to suppress the deterioration of the photo-sensitive layer from the head of the synchronizing signal portion.

[0049] It is also possible to combine the method of adding the dummy data to the head of the write data as in this embodiment and the method of inverting the write data at random mentioned in the first embodiment. This configuration, illustrated in Fig.13, suppresses the deterioration of the photo-sensitive layer at the head or the end of the write data as well as in the write data, so that the optical disk has a longer life.

[0050] A block diagram of a reader/writer as a further embodiment of the invention is illustrated in Fig.16. A flow chart of the process to rewrite a sector performed by this reader/writer is illustrated in Fig.17. After detecting ID (address

data) of the sector to be rewritten in step 1701, a system controller 4 that is connected to a host computer outputs write information 5 in form of binary data (step 1702). This write information 5 is provided with information for error correction in step 1703 and it is encoded in step 1704. On the other hand, each data block to be written in a sector is provided with a synchronizing signal (VFO) from synchronizing signal generator 2 and laser intensity is modulated (step 1705). The laser power controller is switched by selector 38. Then, the laser beam is focused on the optical disk 1 to write the data into the sector of the optical disk. The different point of above operation from that of the prior art is that the laser power (energy) for writing the synchronous signal is not same as the power for writing decoded write data following the VFO.

[0051] Fig.18 shows a timing chart of laser power and written mark where the VFO and the write data are written in the data portion of the same sector. As shown in the laser power (1) in Fig.18, the data following the VFO are written with pulse width modulation and the laser power for writing the VFO is set lower than that for writing the data. Such writing method can suppress the deterioration in VFO due to repeated rewriting since the thermal stress is smaller in the VFO portion than in the data portion.

[0052] One of the other writing methods is shown in the laser power (2) in Fig.18. In this method, both VFO and the write data are written with pulse width modulation, and the pulse interval is longer than the pulse width in the VFO signal portion (at least in the leading part of the VFO portion). Thus, also by this method, the deterioration in VFO due to repeated rewriting is suppressed, since the thermal stress is smaller in the VFO portion than in the data portion.

[0053] The laser power (3) in Fig.18 shows another writing method, where the laser power for writing the VFO is set lower at the beginning than that for writing the data, but it becomes higher step by step up to the power for writing the data. The deterioration in VFO due to repeated rewriting is suppressed for the reason mentioned above also in this method. Since the mark length is varied according to the laser power in this method, the read signal (reproduced waveform) of VFO may not be recognized as a clock with a constant frequency. To solve this problem, VFO is written such that the centers of the marks have a constant pitch and only the centers of the marks are detected when reading the VFO. Alternately, head or tail edge of marks can have a constant pitch and only the head or the tail edge of the marks are detected when reading the VFO.

[0054] It is possible to combine the above writing methods and the method disclosed in Tokukaihei 2-94113 where the relative position of the starting points of writing VFO and data on a optical disk is varied at every writing time.

[0055] It is also possible to write dummy data following the write data The length of the dummy data may be altered according to how often the disk is rewritten. If the disk is supposed to be rewritten many times, dummy data with enough length are necessary. On the other hand, if the disk is rarely rewritten, dummy data may not be necessary

[0056] A concrete example will be explained below A disk was rotated at a linear speed of ten meters per second at the write portion to write a signal. The disk was made by forming a photo-sensitive layer of $Ge_2Te_2Sb_5$ for writing, protecting layers of ZnS and a reflecting layer of aluminum on the substrate of polycarbonate having grooves for tracking Data was written with pulse width modulation by 2-7 RLL (Run Length Limited) code and EFM (Eight to Fourteen Modulation). The shortest mark length and the shortest mark distance were set at 0.8 μ m A Reed-Solomon code was used for error correction. A length of VFO area was set at 50 μm. Writing data into the disk was performed by modulating the laser power between writing power and erasing power according to the data. Power levels for writing, erasing and reading were set at 13 mW, 6 mW and 1 mW respectively. No read error occurred in the center of the data area under above laser power condition. The laser power for writing VFO was altered according to necessities. The laser power for writing VFO marks was adjusted by rewriting data stored in the synchronizing signal generator.

[0057] The deterioration due to repeated rewriting at the head of the VFO was suppressed by lowering the laser power for writing VFO marks, under the condition of the same laser power for writing data and of the same mark period in the VFO area. To lower the laser power, three methods were checked. The first method was to lower the peak level of the laser power; the second method was to shorten the irradiation time: and the third method was a combination of the first and second methods. Any of these methods was effective in suppressing the deterioration.

[0058] Table 3 shows an example of the laser power for writing VFO mark and the length of the read signal waveform deterioration area at the head of the VFO after rewriting 500 thousand times. The VFO marks were written with a mark distance of 1.6 μ m and a duty factor of 50% (corresponding to the shortest mark length in data writing). Pulse width modulation by 2-7 RLL code was used. The length of the waveform deterioration area was defined as the length of the area where the data could not be read correctly. The duty period of the laser power for writing VFO marks was set identically with the laser power for writing the shortest mark of write data.

Table 3

Laser power for writing VFO marks	Length of the deterioration area at VFO head portion	PLL draw in by VFO
13 mW	40 μm	failure
12	33	success

Table 3 (continued)

Laser power for writing VFO marks	Length of the deterioration area at VFO head portion	PLL draw in by VFO
11	5	success
10	50	failure

[0059] It is clear from Table 3 that the length of the deterioration area at the VFO head portion become short if the laser power for writing VFO marks is decreased. Therefore, decreasing the laser power results in good reading of VFO, though too much decreasing makes the amplitude of the read signal small and results in a failure to read.

[0060] Regarding the head of the mark train of data after VFO, there was seen a waveform distortion of approximately 10 μ m. This distortion seems to be caused by rapid change of thermal stress between the VFO area and the data area because the average laser power in the former is smaller than that in the latter. It was confirmed that the distortion of the read signal at a border of the VFO and the data area can be suppressed by increasing the laser power for writing VFO marks slowly up to the average laser power for writing data.

[0061] If dummy data are added to the head of the data following VFO. the deterioration at the border of the VFO and the data area can be ignored, so that the deterioration of the read signal waveform due to repeated writing is eliminated. A writing format of data in a sector by this invention is illustrated in Fig.19. There is no problem if the dummy data cannot be read partly due to repeated writing as long as the original data can be read. Heading information is written at the head of the original data. The length of the dummy data depends on how often the disk is used. The same modulation method can be used for the dummy data and the original data.

[0062] The allowable ratio of the mark distance and the mark length of VFO was investigated under the condition of the same modulation method and laser power for the VFO and the data mark. The result is that the length of the deteriorated waveform is shorter when the ratio (mark distance/length) is bigger than one as compared to when the ratio is one. As a result of further investigation, a better effect is gained when the ratio is more than 1.5, i.e. the length of the deterioration area became less than 60 % of when the ratio is one. It also became clear that decreasing the ratio to one at the end of VFO is effective for lowering the distortion level of the read waveform at the boundary between the VFO and the data mark area. The influence of the deterioration at the boundary on the original data is avoided also in this configuration by writing dummy data at the head of the original data.

Claims

1. A recording and reproducing method for an optical information recording medium in which a light beam is irradiated to change a state of a photo-sensitive record layer, wherein write data to be recorded includes original write data and dummy data (23) added to the head of the original write data and the light intensity is increased slowly in the area of the dummy data (23) before the original write data to be recorded into each sector of the optical information recording medium.

2. A recording and reproducing method for an optical information recording medium in which a light beam is irradiated to change a state of a photo-sensitive record layer, wherein write data to be recorded includes original write data and dummy data (23) following the original write data and the light intensity is decreased slowly in the area of the dummy data (23) after the write data to be recorded into each sector of the optical information recording medium.

3. A recording and reproducing method for an optical information recording medium in which a light beam is irradiated to change a state of a photo-sensitive record layer, wherein write data to be recorded into each sector of the optical information recording medium includes orignal write data and dummy data following the original write data, and wherein the light irradiation energy for forming the mark of the synchronizing signal is smaller at least in a head area than the light irradiation energy for forming the shortest mark of the original data.

4. The recording and reproducing method for an optical information recording medium according to claim 3, wherein the light irradiation energy for forming the mark of the synchronizing signal is smaller in a head area than in a tail area of the synchronizing signal.

5. The recording and reproducing method for an optical information recording medium according to claim 3, wherein a start point of recording in each sector is altered at random.

6. A recording and reproducing apparatus for an optical information recording medium in which a light beam is irra-

diated to change a state of a photo-sensitive record layer, comprising

means (7a) for encoding a write information of predetermined block length into write data;
a first controller that controls the light irradiating energy according to the write data; and
a second controller (35) that increases the light irradiating energy slowly in a dummy data (23) area before the write data.

7. A recording and reproducing apparatus for an optical information recording medium in which a light beam is irradiated to change a state of a photo-sensitive record layer, comprising

means (7a) for encoding write information of predetermined block length into write data;
a first controller that controls the light irradiating energy according to the write data; and
a second controller (35) that decreases the light irradiating energy slowly in a dummy data (23) area after the write data.

Patentansprüche

1. Aufzeichnungs- und Wiedergabeverfahren für ein optische Informationen aufzeichnendes Medium, bei dem ein Lichtstrahl abgestrahlt wird, um einen Zustand einer lichtempfindlichen Aufzeichnungsschicht zu ändern, wobei aufzuzeichnende Schreibdaten ursprüngliche Schreibdaten und zu dem Kopf der ursprünglichen Schreibdaten hinzugefügte Leerdaten (23) enthalten und die Lichthelligkeit in dem Bereich der Leerdaten (23) vor den in jedem Sektor des optische Informationen aufzeichnenden Mediums aufzuzeichnenden ursprünglichen Schreibdaten langsam erhöht wird.

2. Aufzeichnungs- und Wiedergabeverfahren für ein optische Informationen aufzeichnendes Medium, bei dem ein Lichtstrahl abgestrahlt wird, um einen Zustand einer lichtempfindlichen Aufzeichnungsschicht zu ändern, wobei aufzuzeichnende Schreibdaten ursprüngliche Schreibdaten und Leerdaten (23) hinter den ursprünglichen Schreibdaten enthalten und die Lichthelligkeit in dem Bereich der Leerdaten (23) hinter den in jedem Sektor des optische Informationen aufzeichnenden Mediums aufzuzeichnenden Schreibdaten langsam gesenkt wird.

3. Aufzeichnungs- und Wiedergabeverfahren für ein optische Informationen aufzeichnendes Medium, bei dem ein Lichtstrahl abgestrahlt wird, um einen Zustand einer lichtempfindlichen Aufzeichnungsschicht zu ändern, wobei in jedem Sektor des optische Informationen aufzeichnenden Mediums aufzuzeichnende Schreibdaten ursprüngliche Schreibdaten und Leerdaten hinter den ursprünglichen Schreibdaten enthalten und wobei die Lichtabstrahlungsenergie zum Ausbilden der Marke des Synchronisationssignals mindestens in einem Kopfbereich kleiner ist als die Lichtabstrahlungsenergie zum Ausbilden der kürzesten Marke der ursprünglichen Daten.

4. Aufzeichnungs- und Wiedergabe Verfahren für ein optische Informationen aufzeichnendes Medium nach Anspruch 3, wobei die Lichtabstrahlungsenergie zum Ausbilden der Marke des Synchronisationssignals in einem Kopfbereich kleiner ist als in einem Endbereich des Synchronisationssignals.

5. Aufzeichnungs- und Wiedergabeverfahren für ein optische Informationen aufzeichnendes Medium nach Anspruch 3, wobei ein Aufzeichnungsstartpunkt in jedem Sektor zufällig verändert wird.

6. Aufzeichnungs- und Wiedergabeverfahren für ein optische Informationen aufzeichnendes Medium, bei dem ein Lichtstrahl abgestrahlt wird, um einen Zustand einer lichtempfindlichen Aufzeichnungsschicht zu ändern, umfassend:

ein Mittel (7a) zum Codieren einer Schreibinformation vorbestimmter Blocklänge zu Schreibdaten;
eine erste Steuerung, die die Lichtabstrahlungsenergie gemäß den Schreibdaten steuert; und
eine zweite Steuerung (35), die die Lichtabstrahlungsenergie in einem Bereich von Leerdaten (23) vor den Schreibdaten langsam erhöht.

7. Aufzeichnungs- und Wiedergabeverfahren für ein optische Informationen aufzeichnendes Medium, bei dem ein Lichtstrahl abgestrahlt wird, um einen Zustand einer lichtempfindlichen Aufzeichnungsschicht zu ändern, umfassend:

ein Mittel (7a) zum Codieren einer Schreibinformation vorbestimmter Blocklänge zu Schreibdaten;
eine erste Steuerung, die die Lichtabstrahlungsenergie gemäß den Schreibdaten steuert; und
eine zweite Steuerung (35), die die Lichtabstrahlungsenergie in einem Bereich von Leerdaten (23) hinter den Schreibdaten langsam senkt.

Revendications

1. Procédé d'enregistrement et de reproduction pour un support d'enregistrement d'informations optique, dans lequel un faisceau lumineux est rayonné pour changer un état d'une couche d'enregistrement photosensible, dans lequel des données d'écriture devant être enregistrées incluent des données d'écriture de base et des données factices (23) ajoutées à la tête des données d'écriture de base et l'intensité lumineuse est augmentée lentement dans la zone des données factices (23) avant les données d'écriture de base devant être enregistrées dans chaque secteur du support d'enregistrement d'informations optique.

2. Procédé d'enregistrement et de reproduction pour un support d'enregistrement d'informations optique, dans lequel un faisceau lumineux est rayonné pour changer un état d'une couche d'enregistrement photosensible, dans lequel des données d'écriture devant être enregistrées incluent des données d'écriture de base et des données factices (23) suivant les données d'écriture de base et l'intensité lumineuse est diminuée lentement dans la zone des données factices (23) après les données d'écriture devant être enregistrées dans chaque secteur du support d'enregistrement d'informations optique.

3. Procédé d'enregistrement et de reproduction pour un support d'enregistrement d'informations optique, dans lequel un faisceau lumineux est rayonné pour changer un état d'une couche d'enregistrement photosensible, dans lequel des données d'écriture devant être enregistrées dans chaque secteur du support d'enregistrement d'informations optique incluent des données d'écriture de base et des données factices suivant les données d'écriture de base, et dans lequel l'énergie de rayonnement lumineux destinée à former la marque du signal de synchronisation est inférieure au moins dans une zone de tête à l'énergie de rayonnement lumineux destinée à former la marque la plus courte des données de base.

4. Procédé d'enregistrement et de reproduction pour un support d'enregistrement d'informations optique selon la revendication 3, dans lequel l'énergie de rayonnement lumineux destinée à former la marque du signal de synchronisation est inférieure dans une zone de tête à celle dans une zone de queue du signal de synchronisation.

5. Procédé d'enregistrement et de reproduction pour un support d'enregistrement d'informations optique selon la revendication 3, dans lequel un point de départ d'enregistrement dans chaque secteur est aléatoirement altéré.

6. Appareil d'enregistrement et de reproduction pour un support d'enregistrement d'informations optique, dans lequel un faisceau lumineux est rayonné pour changer un état d'une couche d'enregistrement photosensible, comprenant :

   un moyen (7a) destiné à coder des informations d'écriture d'une longueur de bloc prédéterminée en données d'écriture ;
   un premier contrôleur qui commande l'énergie de rayonnement lumineux selon les données d'écriture ; et
   un deuxième contrôleur (35) qui augmente lentement l'énergie de rayonnement lumineux dans une zone de données factices (23) avant les données d'écriture.

7. Appareil d'enregistrement et de reproduction pour un support d'enregistrement d'informations optique, dans lequel un faisceau lumineux est rayonné pour changer un état d'une couche d'enregistrement photosensible, comprenant :

   un moyen (7a) destiné à coder des informations d'écriture d'une longueur de bloc prédéterminée en données d'écriture ;
   un premier contrôleur qui commande l'énergie de rayonnement lumineux selon les données d'écriture ; et
   un deuxième contrôleur (35) qui diminue lentement l'énergie de rayonnement lumineux dans une zone de données factices (23) après les données d'écriture.

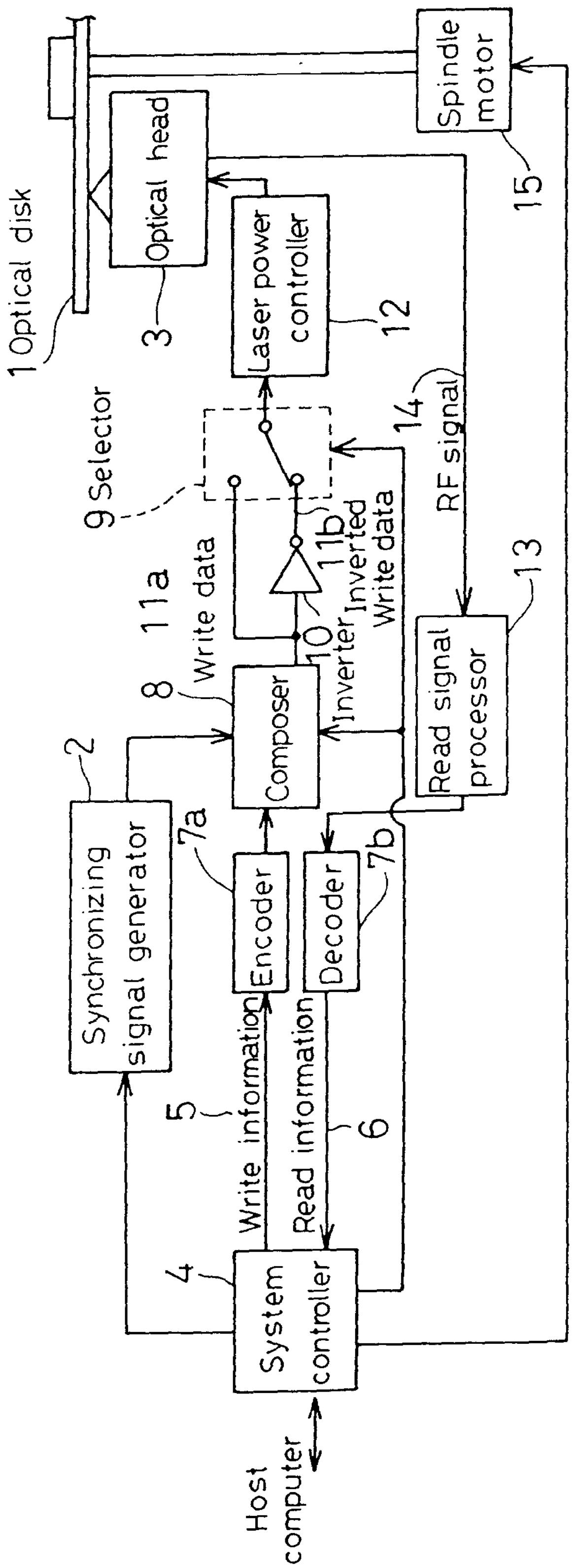

1 Optical disk
3
Optical head
15
Spindle motor
12
Laser power controller
9 Selector
14
RF signal
11a
Write data
11b
Inverted Write data
10
Inverter
8
Composer
13
Read signal processor
2
Synchronizing signal generator
7a
Encoder
7b
Decoder
5
Write information
6
Read information
4
System controller
Host computer

FIG. 1

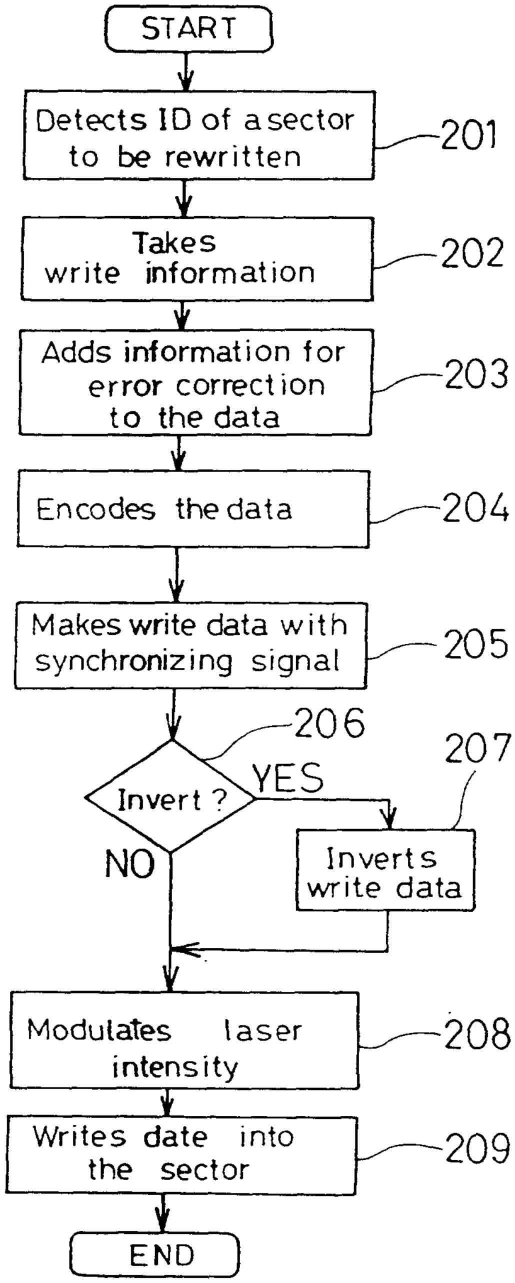

START
Detects ID of a sector to be rewritten
201
Takes write information
202
Adds information for error correction to the data
203
Encodes the data
204
Makes write data with synchronizing signal
205
206
Invert ?
YES
NO
207
Inverts write data
Modulates laser intensity
208
Writes date into the sector
209
END

FIG. 2

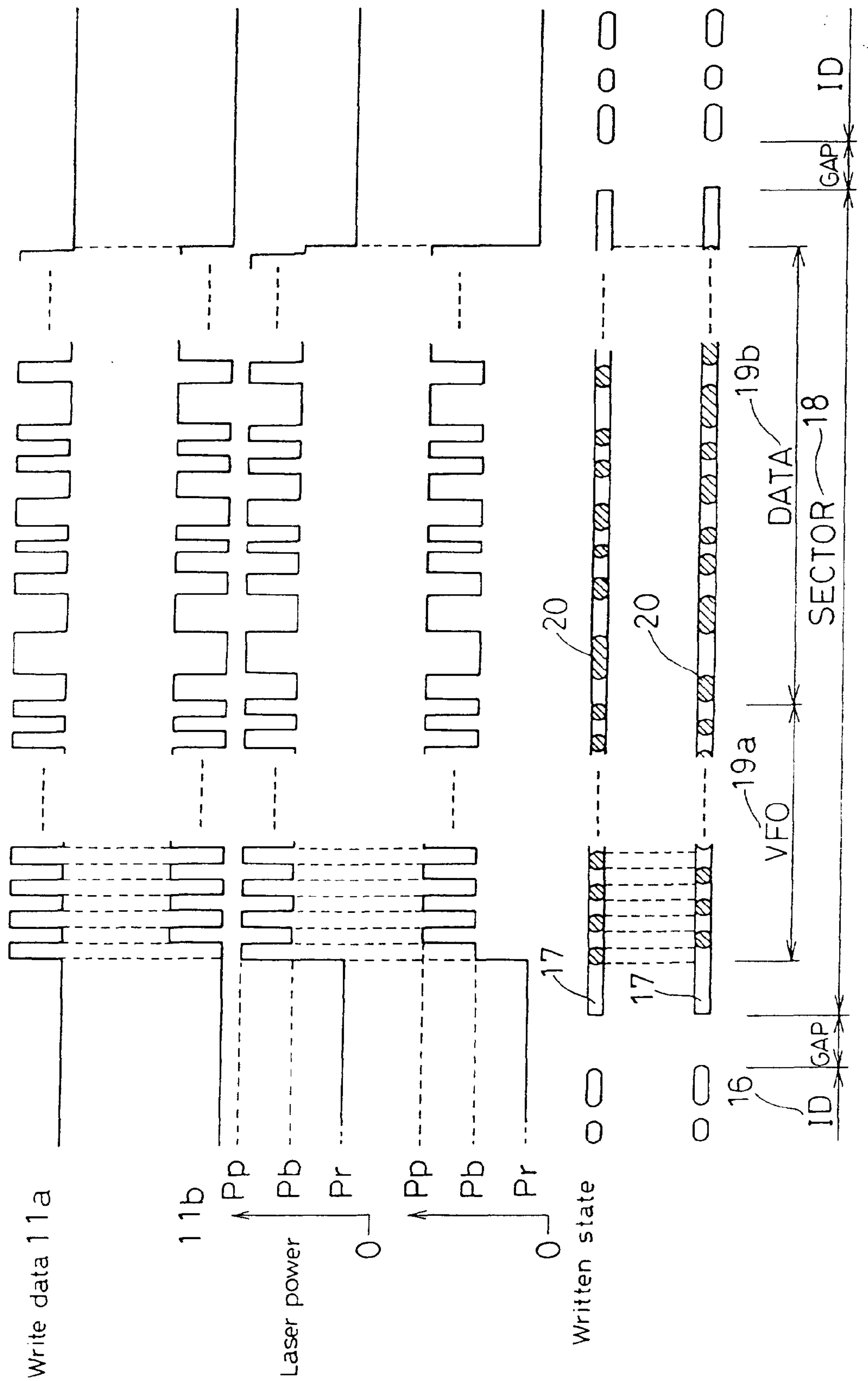

Write data 11a
11b
Laser power
Pp
Pb
Pr
0
Pp
Pb
Pr
0
Written state
16
17
17
20
20
VFO
19a
DATA
19b
SECTOR
18
GAP
GAP
ID
ID

FIG. 3

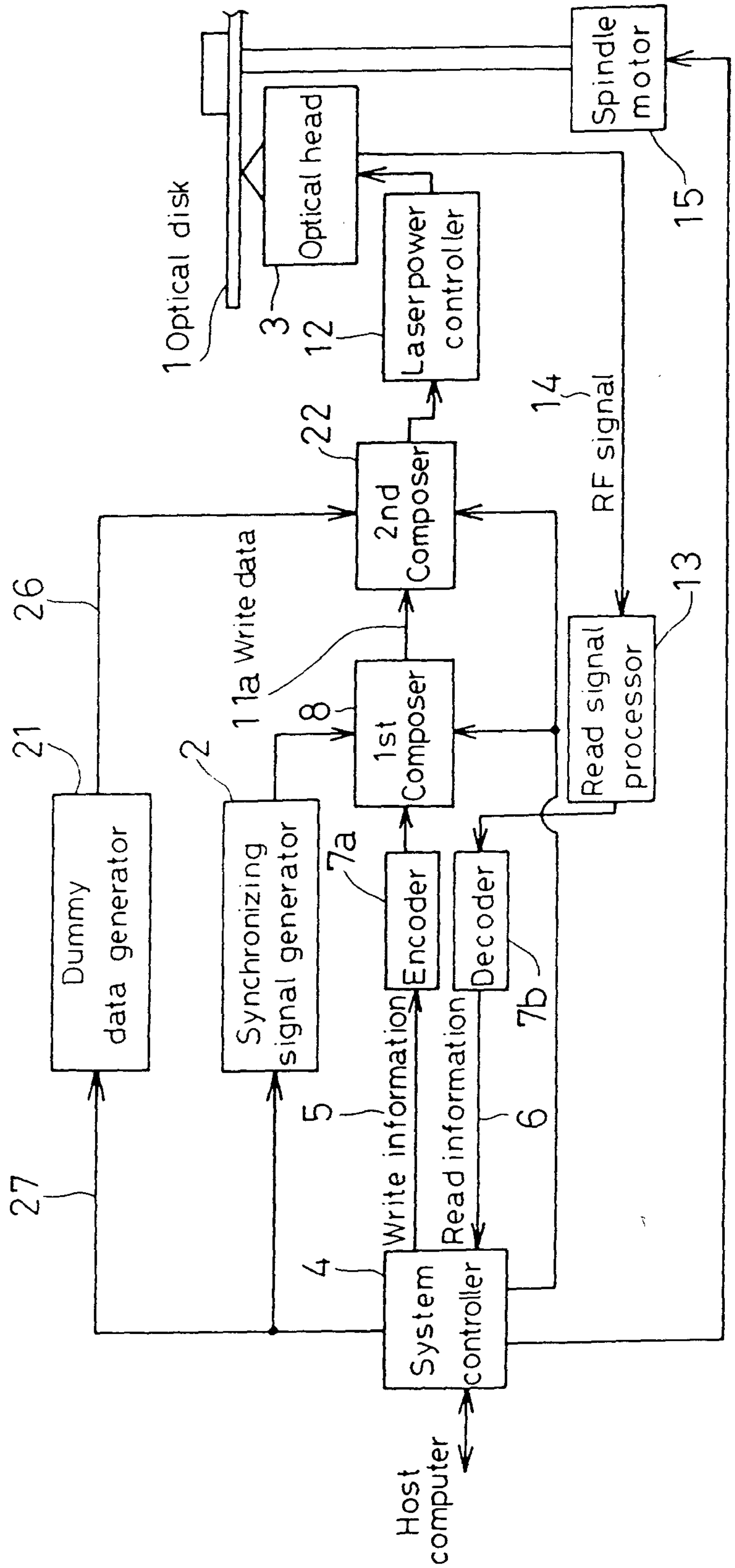

1 Optical disk
3
Optical head
12
Laser power controller
15
Spindle motor
22
2nd Composer
14
RF signal
26
Write data
11a
8
1st Composer
13
Read signal processor
21
Dummy data generator
2
Synchronizing signal generator
7a
Encoder
Decoder
7b
5
Write information
Read information
6
27
4
System controller
Host computer

FIG. 4

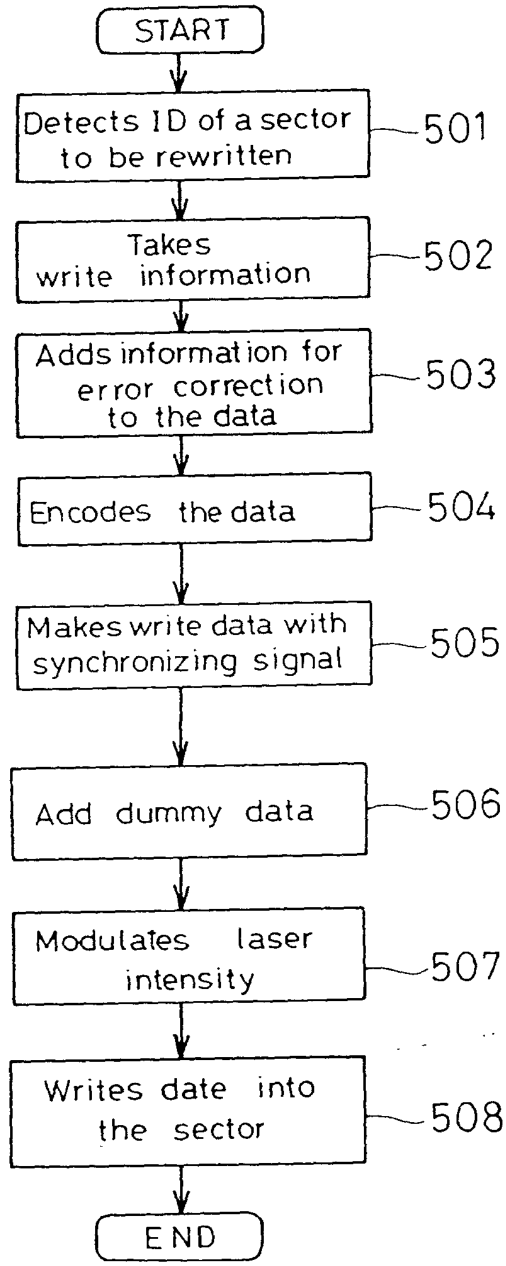

START
Detects ID of a sector to be rewritten
501
Takes write information
502
Adds information for error correction to the data
503
Encodes the data
504
Makes write data with synchronizing signal
505
Add dummy data
506
Modulates laser intensity
507
Writes date into the sector
508
END

FIG.5

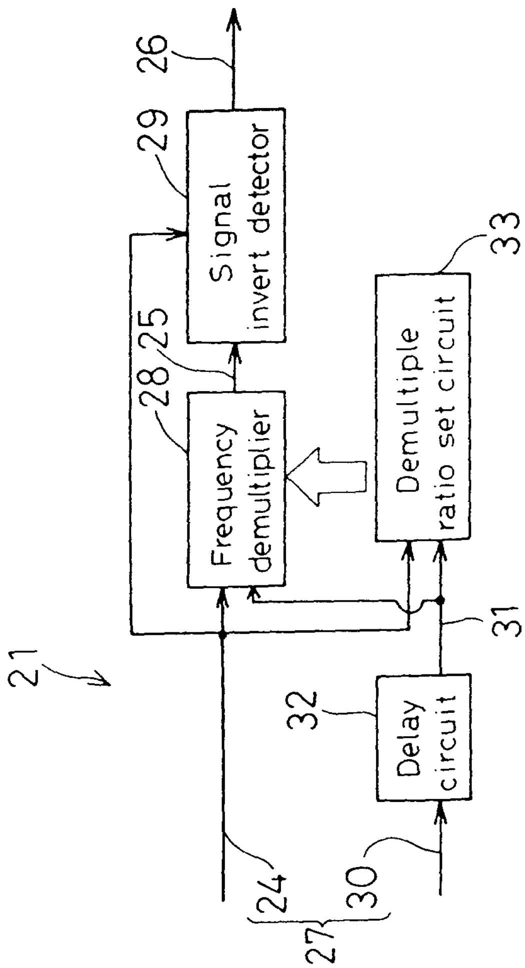

21
Signal invert detector
Frequency demultiplier
Demultiple ratio set circuit
Delay circuit
24
25
26
27
28
29
30
31
32
33

FIG. 6

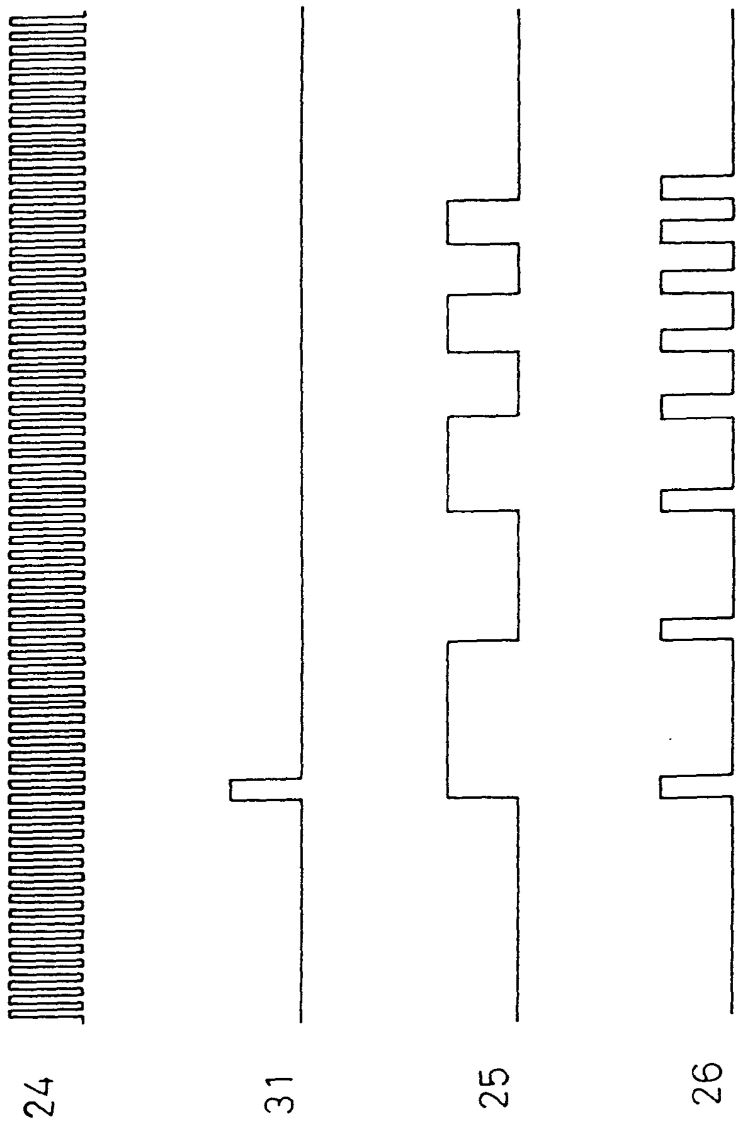


FIG. 7

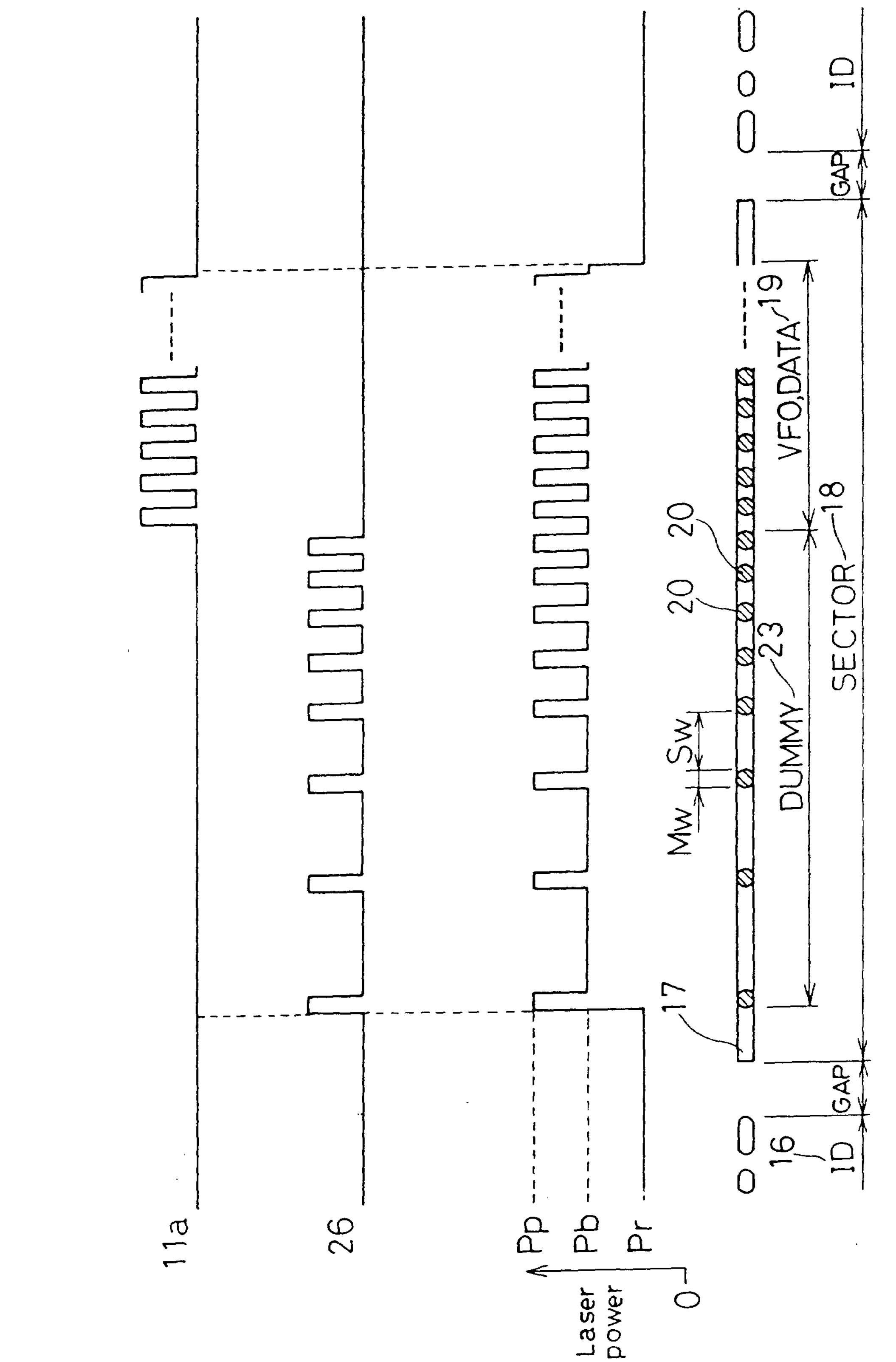

11a
26
Pp
Pb
Pr
Laser power
0
16
ID
GAP
17
DUMMY
23
Mw
Sw
20
20
18
VFO,DATA
19
SECTOR
GAP
ID

FIG. 8

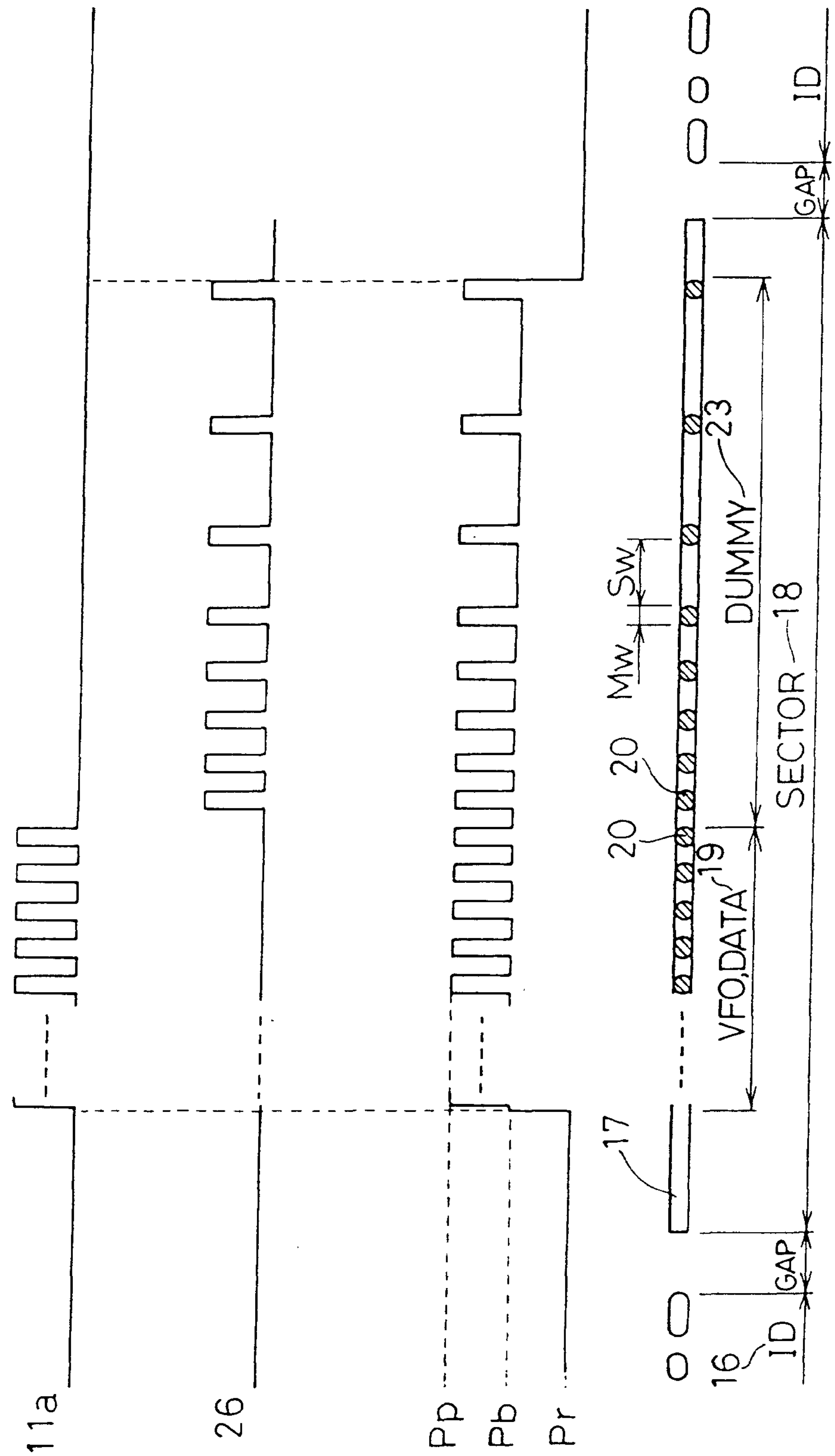
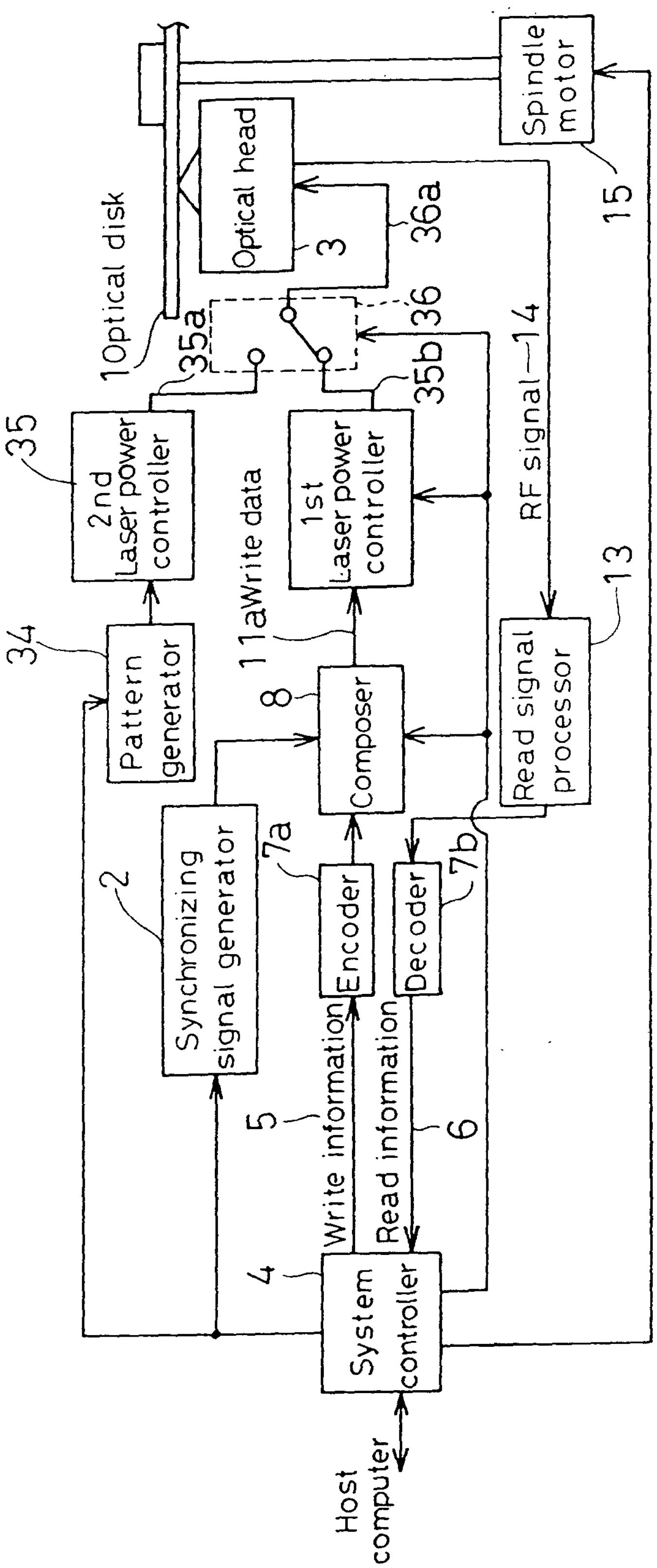

11a
26
Pp
Pb
Pr
16
ID
GAP
17
VFO,DATA
19
20
20
Mw
Sw
DUMMY
23
SECTOR
18
GAP
ID

FIG. 9



1 Optical disk
Optical head
3
36a
36
35a
35b
35
2nd Laser power controller
1st Laser power controller
RF signal
14
Spindle motor
15
34
Pattern generator
11a Write data
8
Composer
13
Read signal processor
2
Synchronizing signal generator
7a
Encoder
7b
Decoder
5
Write information
Read information
6
4
System controller
Host computer

FIG.10

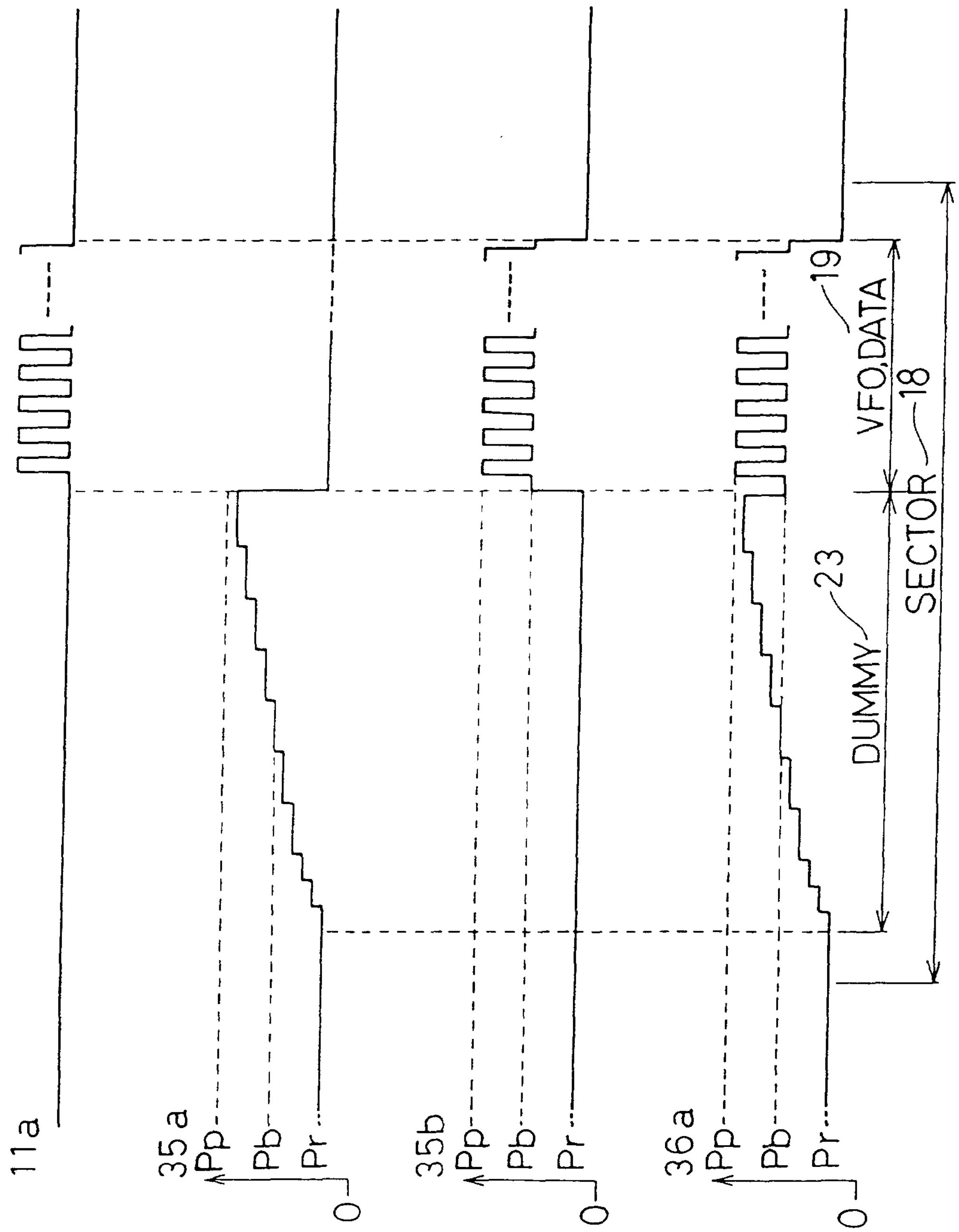

11a
35a
Pp
Pb
Pr
0
35b
Pp
Pb
Pr
0
36a
Pp
Pb
Pr
0
19
VFO,DATA
18
23
DUMMY
SECTOR

FIG. 11

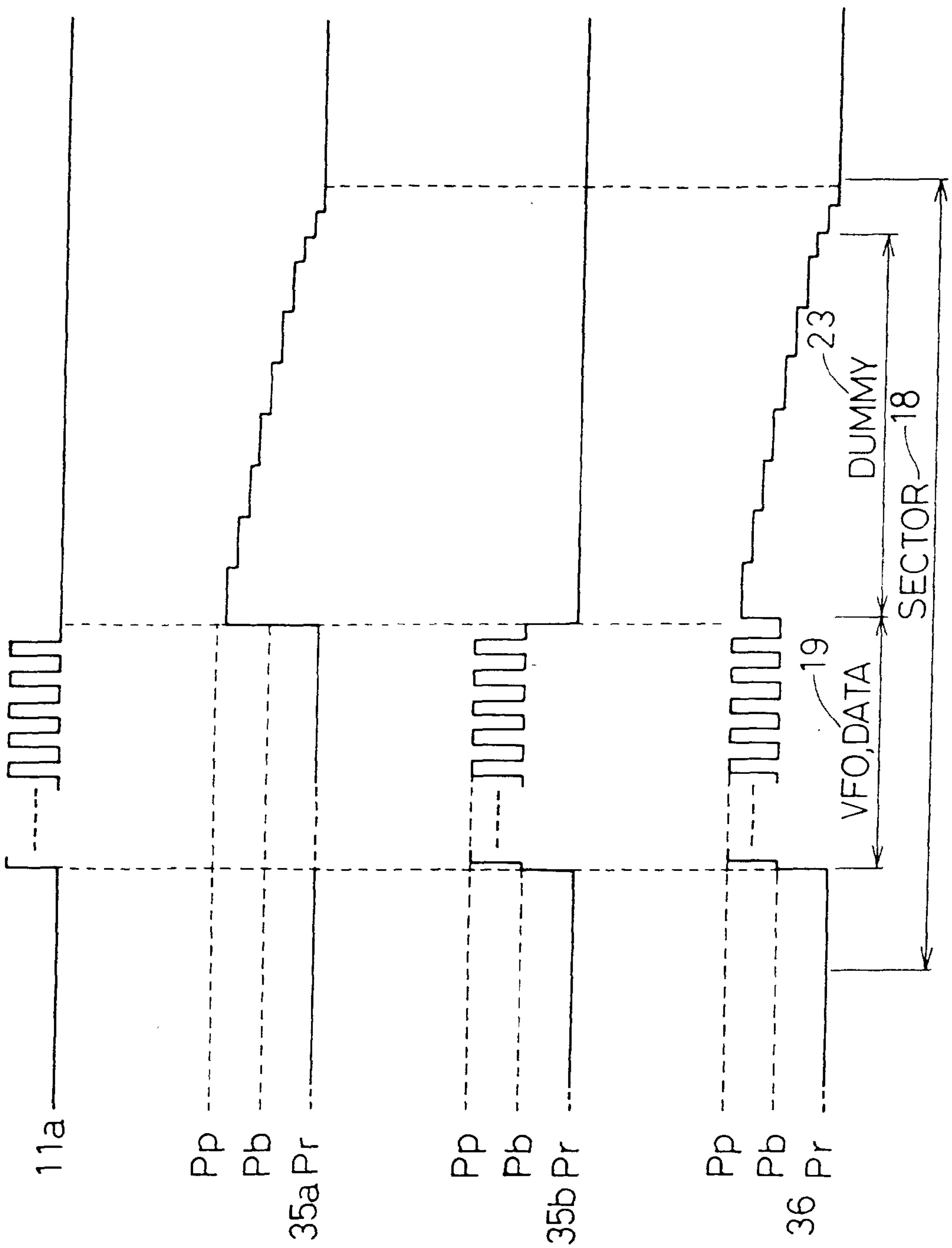
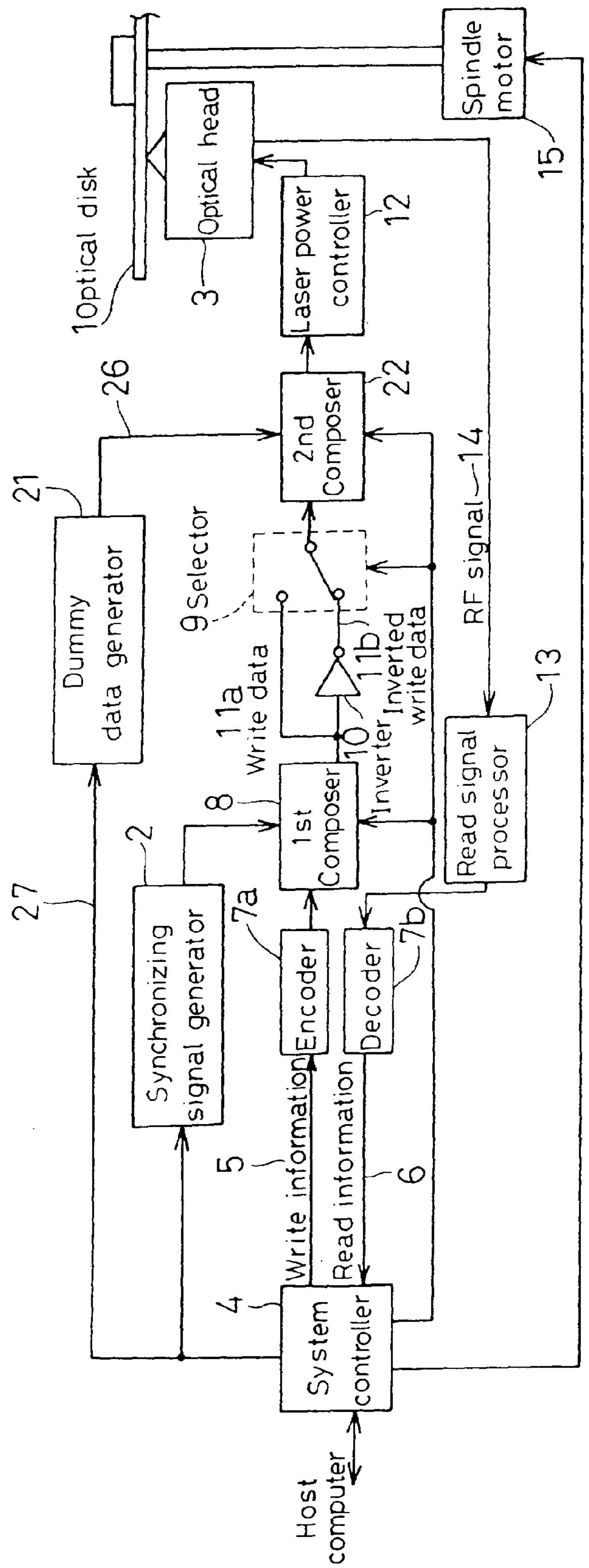

11a
Pp
Pb
35a Pr
Pp
Pb
35b Pr
Pp
Pb
36 Pr
VFO,DATA
19
DUMMY
23
SECTOR
18

FIG. 12


1 Optical disk
3
Optical head
Laser power controller
12
Spindle motor
15
2nd Composer
22
26
21
Dummy data generator
9 Selector
11a Write data
11b Inverted write data
10 Inverter
RF signal
14
13
Read signal processor
8
1st Composer
2
Synchronizing signal generator
27
7a
Encoder
Decoder
7b
5
Write information
Read information
6
4
System controller
Host computer

F I G. 13

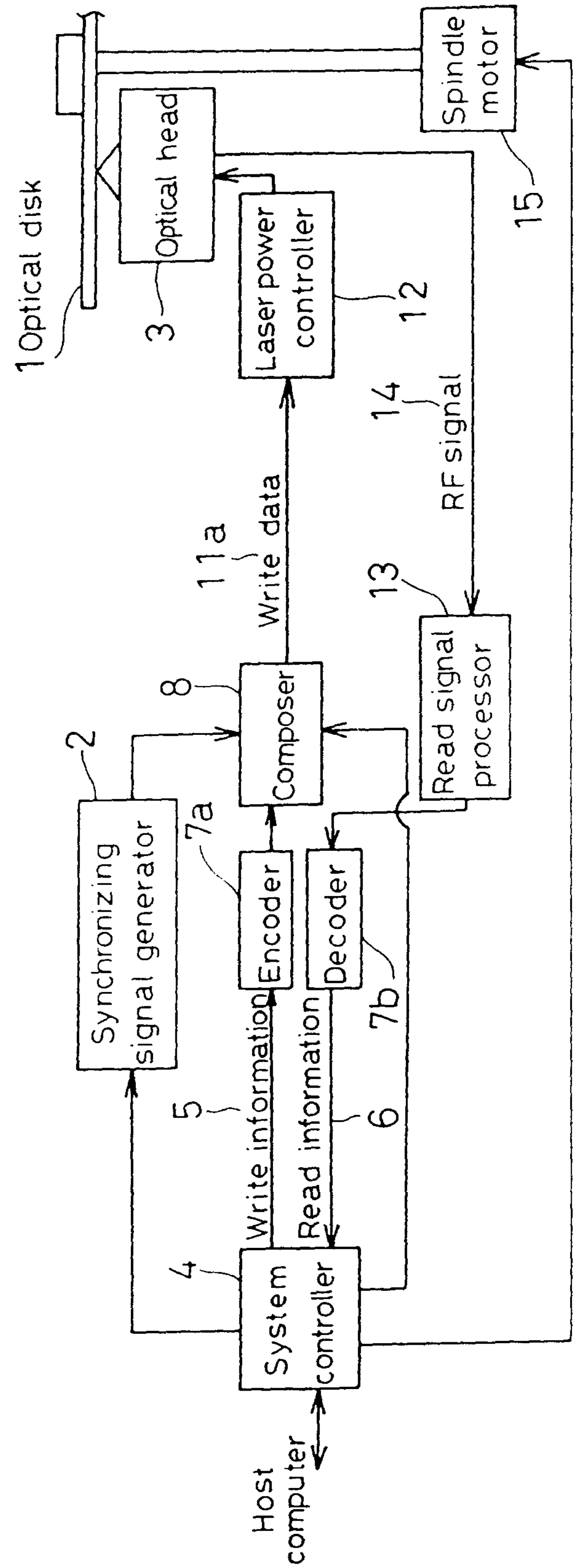


FIG. 14
(PRIOR ART)

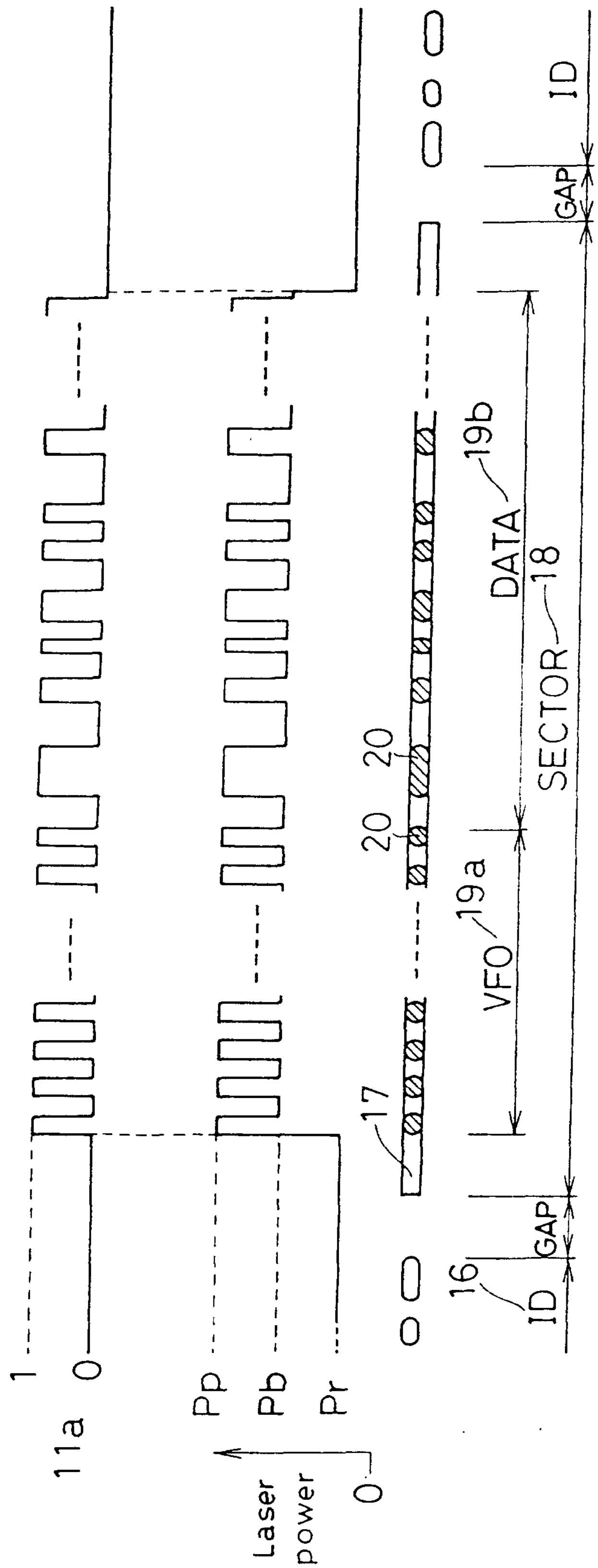
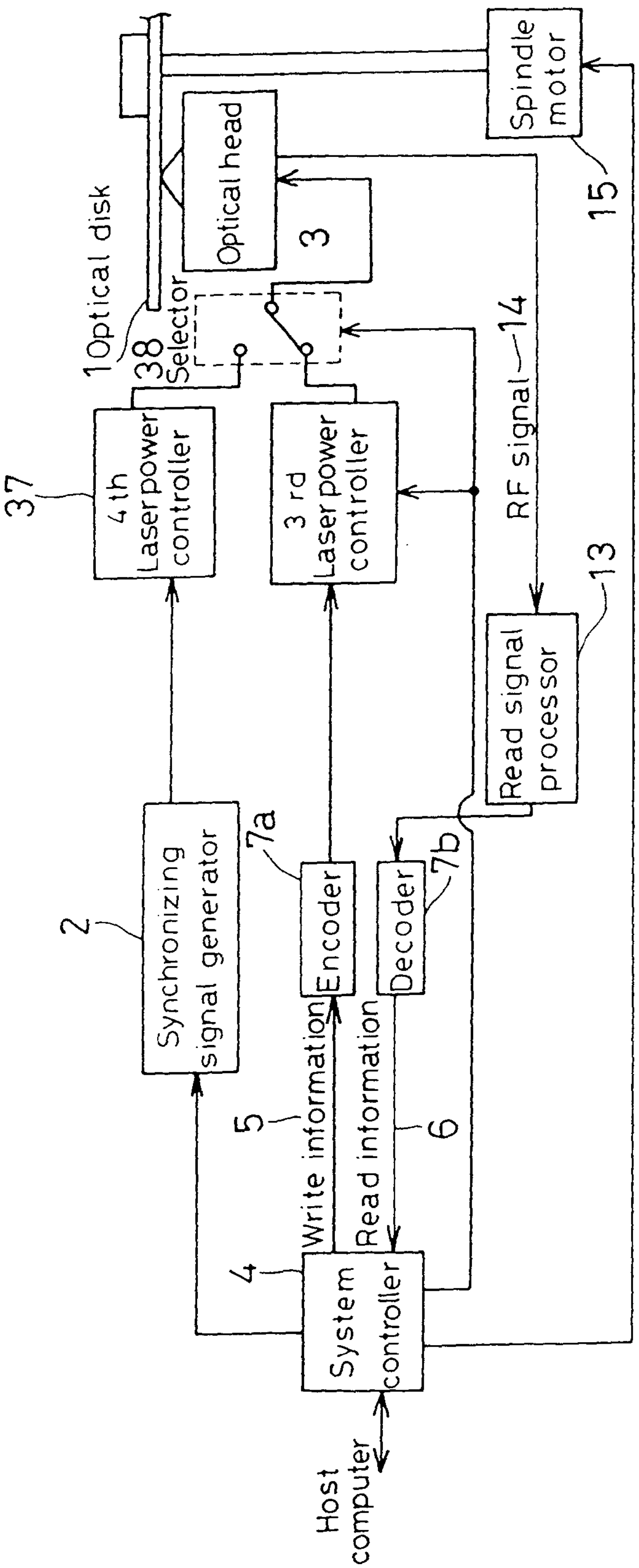


FIG.15
(PRIOR ART)


1 Optical disk
Optical head
3
Spindle motor
15
38
Selector
37
4th Laser power controller
3 rd Laser power controller
RF signal
14
13
Read signal processor
2
Synchronizing signal generator
7a
Encoder
7b
Decoder
5
Write information
Read information
6
4
System controller
Host computer

F I G.16

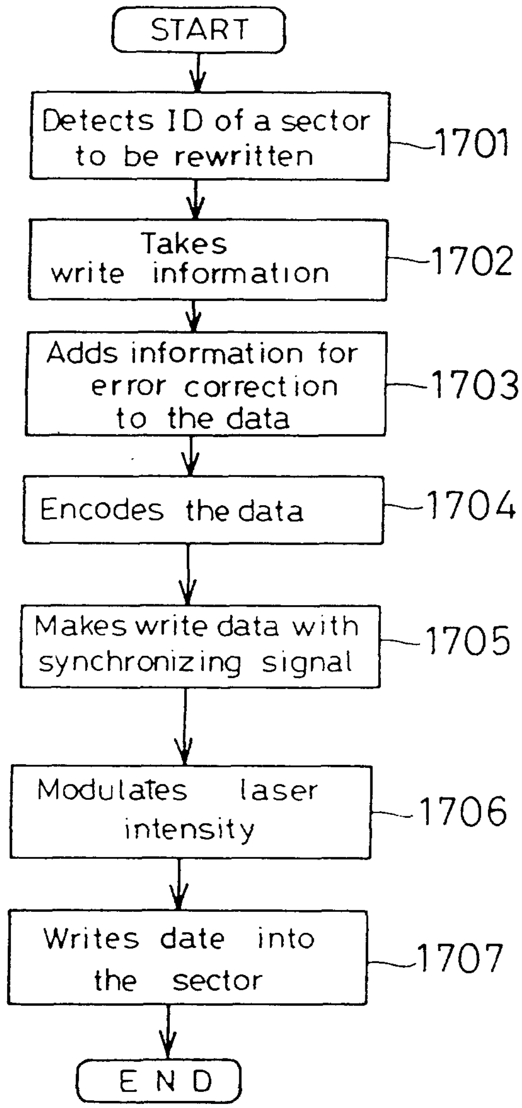

START
Detects ID of a sector to be rewritten
1701
Takes write information
1702
Adds information for error correction to the data
1703
Encodes the data
1704
Makes write data with synchronizing signal
1705
Modulates laser intensity
1706
Writes date into the sector
1707
END

FIG.17

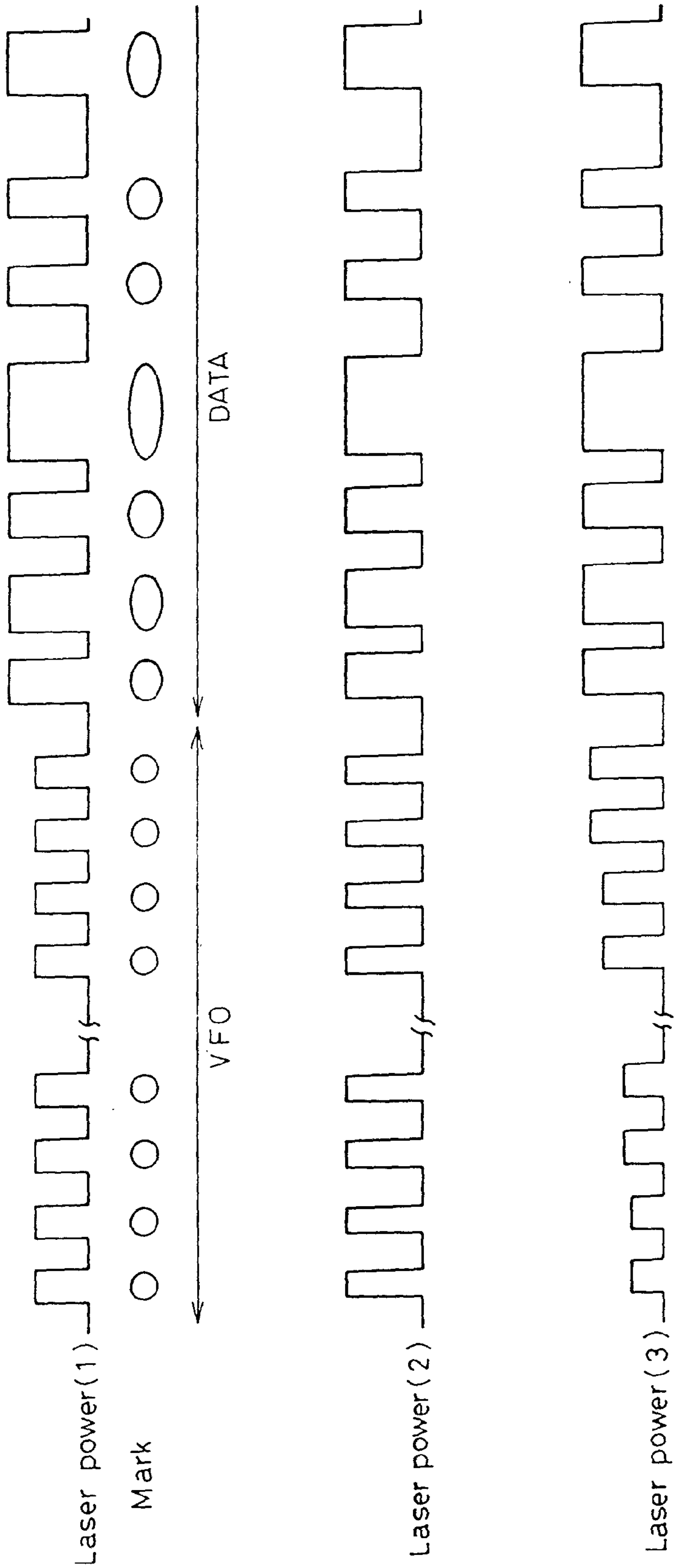


FIG.18

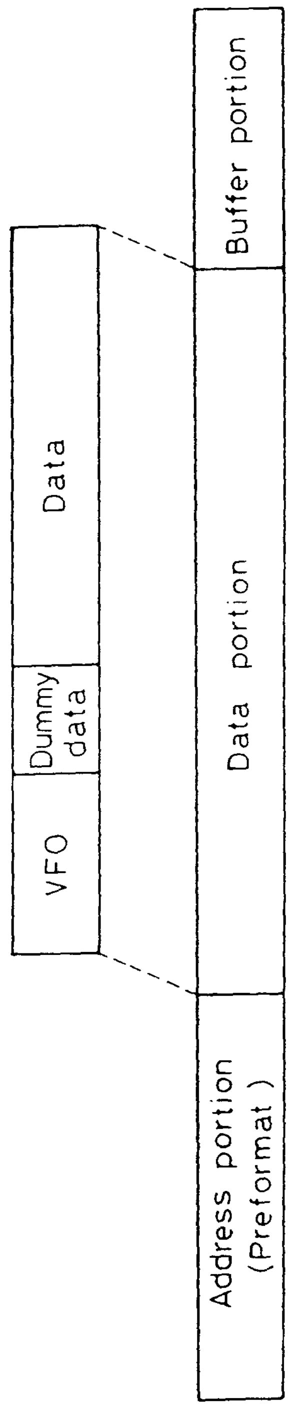

VFO
Dummy data
Data
Address portion (Preformat)
Data portion
Buffer portion

FIG. 19